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THERMOCHEMICAL SCARFING METHOD AND APPARATUS

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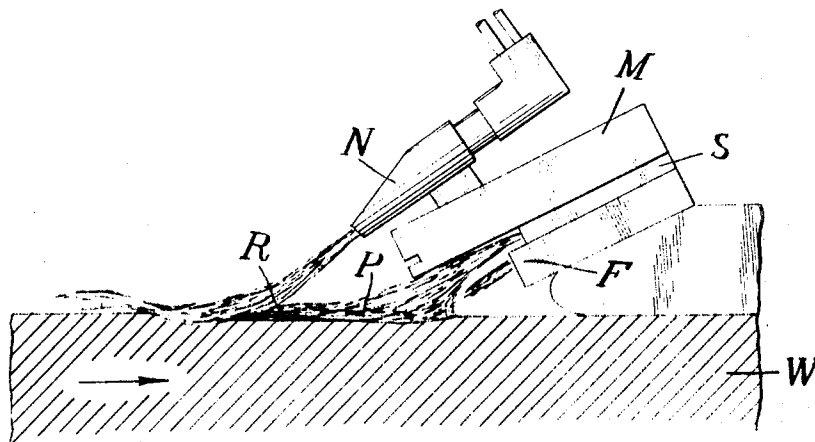


FIG. 1.

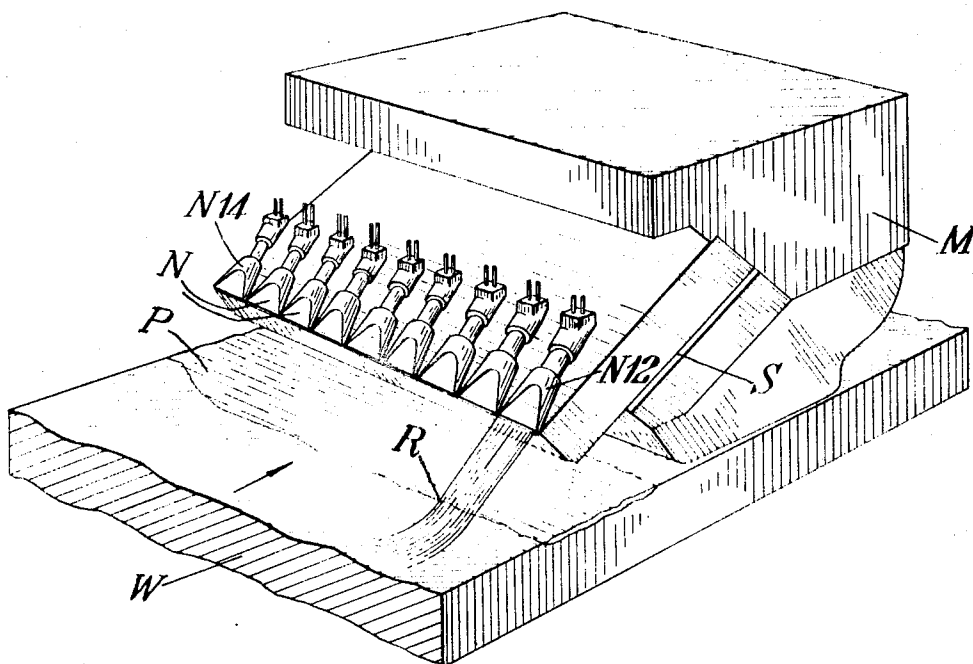


FIG. 2.

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3,455,747 THERMOCHEMICAL SCARFING METHOD AND APPARATUS

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6 Claims

This invention relates to thermochemical scarfing of metal bodies, and while not limited thereto, is particularly valuable when used in conjunction with a selective spot scarfing process as disclosed in United States Patent 3,245,842 issued to A. J. Miller et al.

In selective spot scarfing, individual scarfing nozzles spaced transversely across the path of movement of a metal body, are selectively operated so as to scarf only the areas containing surface defects, in contrast to the more conventional scarfing process wherein an entire surface layer of metal is removed in order to remove the randomly located surface defects therein. The main object of a selective scarfing process is to save metal by scarfing only the scattered narrow areas of the body which contain the defects. Since the defects must be scarfed from the surface while the metal body is moving, it is a fundamental requirement that each scarfing nozzle be capable of making a true flying start on a point just ahead of each defect. It is very difficult to do this because the quantity of heat required to raise the surface area to be scarfed to its ignition temperature in order to make a flying start, is very great.

One method of achieving a flying start is disclosed in United States Patent 3,216,867, issued to J. E. De Vries et al. The method disclosed therein consists of directing a burning adjuvant iron powder at the surface of the metal to be scarfed in order to raise its temperature rapidly to its ignition point and then directing a high pressure stream of scarfing oxygen against the heated surface to produce a flying start.

While the above-mentioned method of producing a flying start has been used successfully, the necessity of utilizing an adjuvant metal powder to provide the heating effect has presented several serious drawbacks. One such drawback is the difficulty of conveying and dispersing the powder in a uniform manner at a point located remotely from the powder dispenser. When the powder valve to a selected scarfing nozzle is opened, the powder issues in a sudden burst, along with the carrier gas which conveys it. If the pressure of the carrier gas is not closely controlled, or if a nozzle becomes partially clogged, the needed amount of powder will not be discharged and directed uniformly at the surface area to be scarfed. This reduces the reliability of the system to make the required flying starts.

By far the greatest drawback, however, is the cost of using metal powders for selective spot scarfing. It has been found, for example, that with a 1 $\frac{1}{16}$ inch wide nozzle, approximately one ounce of iron powder is required per flying start and that about 48 starts are typically required for scarfing the four sides of a 28 foot long 4 by 4 inch billet. From the above it can be seen that at a cost of about \$0.11 per pound of iron powder, the total powder cost for selective scarfing can in many cases outweigh the savings in metal realized through the use of the spot scarfing process.

Another characteristic of the above prior art selective scarfing process, which is considered to be a drawback in certain scarfing applications, is that the individual narrow scarfing nozzles produce longitudinal ridges in the surface of the metal body adjacent the selectively scarfed areas. While this is not a serious factor in most product

applications, it is desirable to eliminate the formation of such ridges.

The applicability of the present invention is not limited to selective spot scarfing. In conventional scarfing processes using a wide sheet-like scarfing oxygen stream for removing an even surface layer of metal, it is usually necessary to regulate the depth of the scarfing cut to correspond to the depth of the deepest defect. The result of this requirement is that a substantial amount of clean defect-free metal must be wasted in order to produce a uniform, defect-free surface in the final product. In certain instances where the same grade of steel is being produced, the present invention enables a deeper cut to be taken in the areas of deepest defects and a shallow cut to be taken in the remaining areas.

The main object of the present invention is to provide a novel method and apparatus for the selective spot scarfing of metal bodies without the need for adjuvant metal powders.

Another object is to provide a novel selective scarfing method and apparatus which leaves the scarfed surface smooth and substantially free of longitudinal ridges.

Still another object of this invention is to provide a scarfing method and apparatus wherein an entire width of the surface layer of a metal body is removed in such manner that the depth of the cut is greater in selected areas containing the deepest defects and shallow in the remaining areas.

According to this invention, the first two objects are satisfied by preheating a transverse area of the surface of the metal body in order to form an elongated molten slag-iron puddle thereon. In order to keep this puddle molten, a wide sheet-like stream of oxygen is directed against the preheated area, at an acute angle thereto. This produces an exothermic thermochemical reaction, liberating sufficient heat to maintain the puddle molten. As will be explained hereinafter, the purpose of this puddle, according to this embodiment is to act as a pilot puddle from which flying starts can be made and also to finish up the scarfing reaction and thereby remove any ridges formed in the selectively scarfed surface of the body. Accordingly, the flow rate of oxygen discharged is maintained at a low rate which is sufficient to produce only a shallow depth scarfing cut.

Selected surface defects in the metal body are removed by directing at least one individual stream of scarfing oxygen against the rearward portion of the molten puddle at transverse points in substantial alignment with such defects. The individual scarfing oxygen streams are discharged at a flow rate sufficient to increase the combined metal removal to a depth equal to that of the deepest defect. However, these streams are operated intermittently whereas the wide sheet-like stream is discharged continuously over the entire length of the body to be scarfed. In this manner, the spaced surface defects are removed by the selectively discharged individual oxygen streams. The sheet-like oxygen stream maintains the entire reaction area molten so that the individual scarfing oxygen streams will produce a true flying start upon impinging against the molten area. The sheet-like stream also produces a shallow planing action as relative movement is produced between the scarfing apparatus and the metal body. This planing of the body cleans and smoothes the selectively scarfed areas by at least partially removing the ridges formed by the selectively discharged individual scarfing oxygen streams.

To continue the scarfing reactions along the surface length of the metal body, relative movement is produced between such body and the streams of oxygen. Usually, the initial preheating of a transverse surface area to form the elongated slag-iron puddle, as above-mentioned, is performed while the metal body and scarfing apparatus

are in a fixed position relative to one another. Thereafter, the remaining steps of the process are performed as relative movement between the metal body and the scarfing apparatus is produced.

On most grades of cold steel it has been found preferable to discharge the sheet-like oxygen stream at a flow rate of the order of 3500-5000 c.f.h. per inch of steel surface width. At scarfing speeds of 30 to 100 feet per minute, this will produce a complete surface removal to a depth of about .20 to .06 inch. Each selective individual scarfing oxygen stream, when intermittently discharged, is preferably discharged at a flow rate of about 4000 to 5000 c.f.h. per inch of surface width covered thereby. At the above-mentioned scarfing speeds this flow will increase the depth of cut in the selected areas containing surface defects to the order of .40 to .14 inch.

On most grades of hot steel it has been found preferable to discharge the sheet-like oxygen stream at a flow rate of about 3000-4500 c.f.h. per inch of steel surface width. At scarfing speeds of 50 to 250 feet per minute, this will produce a complete surface removal to a depth of the order of .20 to .05 inch. Each selective individual scarfing oxygen stream, when intermittently discharged, is preferably discharged at a flow rate of about 3500 to 4500 c.f.h. per inch of surface width covered thereby. At the above-mentioned scarfing speeds, this flow will increase the depth of cut in the selected areas containing surface defects to about .40 to .10 inch.

The third object of this invention may be accomplished according to the invention by discharging the wide sheet-like oxygen stream at high pressure and in a conventional manner so as to produce a normal scarfing cut, but of a depth commensurate with the depth of the greatest number of defects. In a particular scarfing application this depth will usually remain relatively constant. The areas containing deeper defects are scarfed to a greater depth by directing selective narrow streams of oxygen slightly ahead of the wide sheet-like oxygen stream at points longitudinally in line with the deepest defects. In many scarfing applications wherein the same size and grade of material is continuously conditioned, the areas containing the deepest defects also remain substantially constant, as for example, adjacent the edges of the material. In such case, the flow rate of oxygen from the wide sheet-like scarfing stream can be enriched with additional oxygen at points adjacent the edges to obtain a resultant deeper scarfing cut at these locations as compared with the remaining surface width.

Apparatus is provided according to the invention, consisting of a wide continuous slot scarfing unit, in combination with a plurality of individual nozzles. Each nozzle is adapted to discharge a stream of oxygen slightly downstream of the sheet-like stream of oxygen discharged from the continuous slot scarfing unit. The continuous slot scarfing unit is preferably of the type disclosed and claimed in U.S. Patent 2,838,431 issued to W. Allmang et al.

In the drawings:

FIGURE 1 is a side elevational view of the scarfing apparatus of the invention shown in operation after the metal body has been preheated and the molten slag-iron puddle formed; and

FIGURE 2 is a plan view of the scarfing apparatus shown in FIGURE 1.

Referring to the drawings, the invention will first be described in conjunction with a selective scarfing process. As shown therein, the surface of a metal body W is initially preheated with fuel gas from ports F and a low flow of oxygen from the continuous slot S in scarfing unit M, to form an elongated transverse slag-iron puddle P thereon. During this initial preheating period the metal body W and scarfing unit M remain stationary. As soon as the puddle is formed, the flow of oxygen from slot S is adjusted to a value sufficient only to produce a shallow depth scarfing cut as shown in FIGURE 1, and the flow

of fuel gas from ports F is reduced to a value sufficient to stabilize the sheet-like configuration of the oxygen stream. The relatively low flow of oxygen impinging against the preheated area causes a thermochemical reaction which liberates sufficient heat to maintain the puddle molten during the selective scarfing operation, as will be further described hereinafter. It is important that this puddle remain molten, as it enables true flying starts to be made without the use of adjuvant metal powders.

About the time the elongated molten puddle has been formed and the flows of oxygen and fuel gas adjusted as above-described, relative movement is produced between the metal body W and the oxygen stream S, for continuing the thermochemical reaction along the length of the body. As this relative movement continues, selective defects in the body surface are removed by directing one or more oxygen streams from one or more nozzles N, against the rearward portion R of the elongated molten puddle P at points in substantial alignment with the defects. As the selected streams of oxygen strike the rearward portion of the molten puddle, a flying start is produced, which continues for the length of the defect, which is thereby scarfed from the surface. The nozzles N are intermittently operated, and are capable of firing independently of one another, so that oxygen is discharged therefrom only when selective defects in the body surface pass in substantial alignment with one or more of them.

The operation of the nozzles N may be controlled manually or automatically. A novel control system for automatic operation of individual nozzles during selective scarfing is disclosed and claimed in U.S. Patent 3,245,842 issued to A. J. Miller et al. This reference teaches several methods for locating defects, recording the relative locations thereof on a memory device, e.g. a magnetic tape, and automatically transmitting the so recorded information from such memory device to energize solenoid type valves in the gas supply line feeding a given blowpipe, at the precise time that the defect enters the firing range thereof. The disclosure of the Miller et al. patent is incorporated herein by reference, to the extent pertinent.

Depending upon the depth of the defects, the selective nozzles N may produce ridges in the metal surface, outlining the location of removed defects. In certain scarfing applications, these ridges may produce undesirable effects in the subsequently formed product. In the present invention, however, the wide sheet-like oxygen stream S produces an even shallow depth cut which at least partially smoothes out any ridges which may have been formed by the selective individual oxygen streams from nozzles N.

Each of the nozzles N should be capable of discharging 3500-5000 c.f.h. of oxygen per inch of surface width over which it is operable, and may be constructed so as to discharge any convenient shape of stream, e.g. circular or flat-shaped.

Independent valving should be provided for supplying each nozzle or each small group of nozzles with oxygen. The control system for energizing these valves is preferably constructed as disclosed in U.S. Patent 3,245,842 issued to A. J. Miller et al.

This invention is not limited in scope to selective spot scarfing. In the more conventional scarfing process, there are certain applications, particularly when scarfing the same type product, where the metal surface to be scarfed frequently contains deeper defects at a particular location, e.g. adjacent the edges, than across the remainder of its width. According to the present invention, a substantial reduction in metal loss can be achieved by adjusting the flow rate of the main scarfing oxygen stream S to a value sufficient to scarf the body to a depth corresponding to that of most of the defects. This flow rate will usually be of the order of 4000 to 5000 c.f.h. per inch of surface width for most cold steel scarfing applications, and 3000 to 4000 c.f.h. per inch of surface width for

hot scarfing. The scarfing speed in such instances will usually be about 50 to 90 feet per minute when scarfing cold steel, and 90 to 150 when scarfing hot steel. To achieve a deeper scarfing cut in the portion of the body having consistently deeper defects, the nozzles N substantially in alignment with these areas are turned on and remain on during at least a part of the entire scarfing pass. Thus, for example, if the areas of deepest defects were adjacent the edges of the body, nozzles N12 and N14 would be operated so as to enrich the oxygen concentration of the main oxygen stream S in these areas, thereby producing deeper scarfing cuts at these locations than across the remaining surface width of the body. The extra oxygen can be introduced in small width increments of about one inch, although greater width increments may also be used with success. When introducing this oxygen to the sheet-like main stream it is important to direct it slightly ahead of the mainstream in order to eliminate the formation of fins and wash on the scarfed surface.

What is claimed is:

1. A method for thermochemically scarfing the surface of a metal body which comprises:

- (a) forming a molten slag-iron puddle across the width of the surface of the metal body;
- (b) maintaining said puddle in a molten state by directing a sheet-like stream of oxygen against the puddle at an acute angle thereto, thereby producing an exothermic chemical reaction;
- (c) selectively scarfing out defects in the surface of the metal body by directing at least one individual stream of scarfing oxygen against the rearward portion of said puddle at points in substantial alignment with said defects, and
- (d) producing relative movement between the body and said stream of oxygen for continuing the scarfing reaction along the length of the metal body.

2. Method as claimed in claim 1 wherein said sheet-like stream of oxygen is discharged at a flow rate sufficient to produce only a shallow depth scarfing cut, so as to partially smooth out any ridges which are produced by said individual narrow streams of scarfing oxygen.

3. Method as claimed in claim 1 wherein said sheet-

like stream of scarfing oxygen is discharged to produce a normal scarfing cut, and said individual streams of oxygen discharged over narrow portions of the surface width are positioned over selected areas which require a deeper cut than is produced by said sheet-like stream.

4. Method as claimed in claim 2 wherein said sheet-like stream of oxygen is discharged at a flow rate of the order of 3500-5000 c.f.h. per inch of surface width during the scarfing of cold steel and said narrow selective streams of oxygen, when intermittently discharged, are discharged at a flow rate of the order of 4000-5000 c.f.h. per inch of surface width covered thereby, and the rate of relative movement is 30-100 feet per minute.

5. Method as claimed in claim 2 wherein said sheet-like stream of oxygen is discharged at a flow rate of the order of 3000-4500 c.f.h. per inch of surface width during the scarfing of hot steel, and said narrow selective streams of oxygen, when intermittently discharged, are discharged at a flow rate of the order of 3500-4500 c.f.h. per inch of surface width covered thereby, and the rate of relative movement is 50-250 feet per minute.

6. A thermochemical scarfing apparatus comprising in combination a wide continuous slot scarfing unit adapted to discharge a sheet-like oxygen stream across the width of a surface to be scarfed, and a plurality of individual nozzles each adapted to discharge a stream of oxygen, said individual nozzles being positioned so as to discharge their respective streams slightly ahead of the sheet-like oxygen stream discharged from said continuous slot scarfing unit.

References Cited

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3,322,578	5/1967	Thompson	148—9.5

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